



Union of Compact Accelerator-Driven Neutron Sources I & II

Design progress of the SANS instrument at CPHS

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Abstract

Progress has been made since we presented the preliminary physical design of the new time-of-flight SANS instrument at the Compact Pulsed Hadron Source (CPHS) in Tsinghua University during the UCANS-I meeting. The final physical design of the SANS instrument was approved in January 2011 and engineering construction has begun. The design of collimator and beamline shielding is completed. A prototypical bandwidth chopper was fabricated and initial tests of the mechanical performance were satisfactory. An evaluation of two in-house-made LPSDs carried out at Hokkaido University showed a reasonable pulse-height spectrum and an as-expected spatial resolution of 8mm . The design of the front-end electronics and data acquisition system are currently under way.

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1. Introduction

The Compact Pulsed Hadron Source (CPHS), is a multi-purpose neutron and proton facility currently under construction at Tsinghua University [1]. It includes a small 13-MeV proton-linac-driven neutron source. It will provide unique experimental tools for students to learn the science and techniques of proton accelerators and neutron scattering on the university campus. It complements China's other neutron sources such as the CSNS, CARR and accelerator facilities. At the international scale, CPHS works closely with other hadron facilities such as those of the LENS-USA and PEFK-Korea on a common goal of developing advanced neutron and proton sources.

The time-of-flight (TOF) small-angle neutron scattering (SANS) diffractometer is one of the first instruments to be built at CPHS for studying large structures in various materials. The final instrumental design and the recent progress on the SANS instrument are described in this work.

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2. Design of the SANS instrument

We presented the physical design of the SANS instrument at CPHS in the UCANS-I meeting [2]. Some minor modifications are made and the physical design was finally reviewed on Jan 2011. The total instrument length is still 8 m with sample position at 5 m from the moderator. The scattering vessel is changed to a square cone and an optional position for high angle detector is added. The schematic three-dimension layout of the SANS instrument is shown in Fig.1 and Table.1 summarizes the parameters of the SANS instrument.

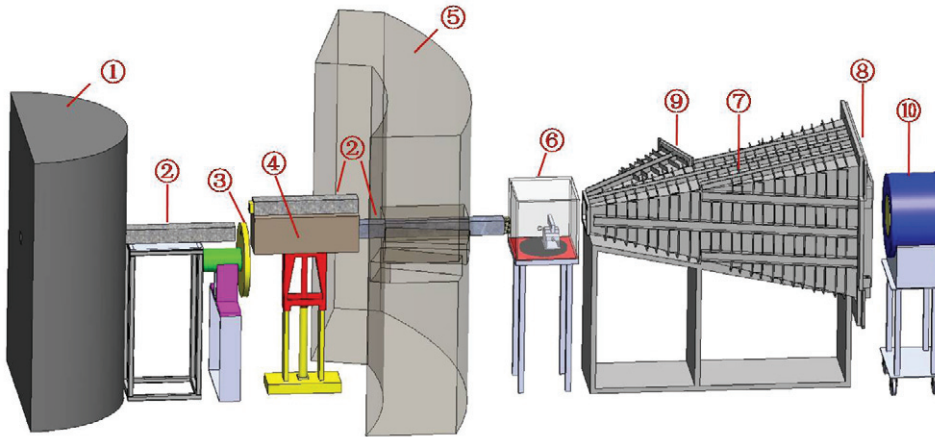


Fig. 1: The schematic 3D layout of CPHS: (1) TMR assembly, (2) collimator, (3) bandwidth chopper, (4) shutter, (5) biological shielding, (6) sample chamber, (7) scattering tank, (8) ^3He LPSDs, (9) high angle detectors, (10) beam dump.

Table 1: Design parameters of the SANS instrument

| Parameter | Design Value |
|-----------------------------|-------------------------------------|
| Source Frequency | 50 Hz |
| Wavelength Range | 1 – 10 Å |
| Source-to-Sample Distance | 5 m |
| Sample-to-Detector Distance | 3 m |
| Collimation | Circular pinhole collimation |
| Sample Size | 1 – 2 cm diameter |
| Area Detector | ^3He LPSD Array |
| Active Area | $1 \times 1 \text{ m}^2$ |
| Pixel Size | 12 mm |
| Q-Range | $0.007 - 1 \text{ Å}^{-1}$ |
| Q-resolution | 2% – 30% |
| Flux at sample position | $\sim 10^4 \text{ n/cm}^2/\text{s}$ |

3. Related R&D

3.1. Bandwidth chopper

A bandwidth chopper is needed to select the working wavelength range from the source spectrum. A prototypical chopper has been built by Institute of Technical Physics, department of Engineering Physics.

It's a simple disk chopper with permanent magnet synchronous motor. High accuracy position control is achieved using a photoelectric encoder. Preliminary experiment result shows that approximate $7\ \mu\text{s}$ phase control accuracy can be achieved. The technique for neutron absorber is still under research.

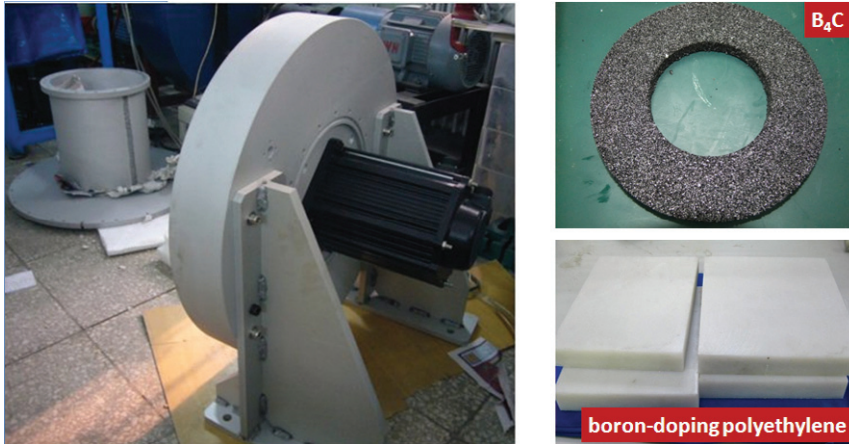


Fig. 2: (a) The prototypical bandwidth chopper; (b) Technique experiments for different shielding materials.

3.2. Collimator and shielding material

Boron carbide will be used for pin-hole collimator. Sintered B_4C is the best material for collimator but difficult to make. B_4C with epoxy resin is easier to make but with relatively poor performance. Boron-doping polyethylene is used for beamline shielding to minimize the escape of high energy neutrons and to decouple the beam from its surroundings. Also the inner surfaces of the scattering tank is covered with B_4C sheets to prevent strayed neutrons from reaching the detector. Different techniques of such materials are experimented and some samples have been made, as shown in Fig.2(b).

3.3. LPSDs experiment

Two prototypical ^3He LPSDs ($L = 1\text{m}, \Phi = 12\text{mm}$) have been made and the detailed structure and preliminary test results were described in previous paper [3]. To further quantitatively evaluate these LPSDs we carried out an experiment at the 45MeV electron linac at Hokkaido University, using the DAQ system made by KEK [4]. The experiment results showed that $\sim 8\text{mm}$ position resolution could be attained.

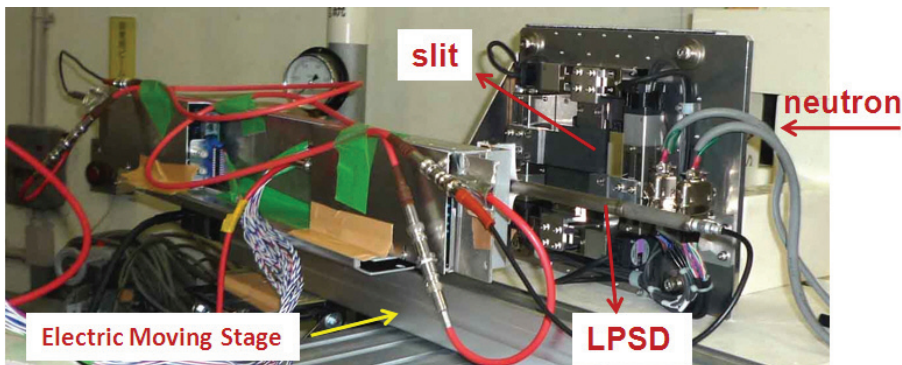


Fig. 3: The experiment setup at Hokkaido University's linac. The PSD was put downstream a adjustable B_4C slit and it's moved a fixed distance along the axial direction each time by a electric moving stage.

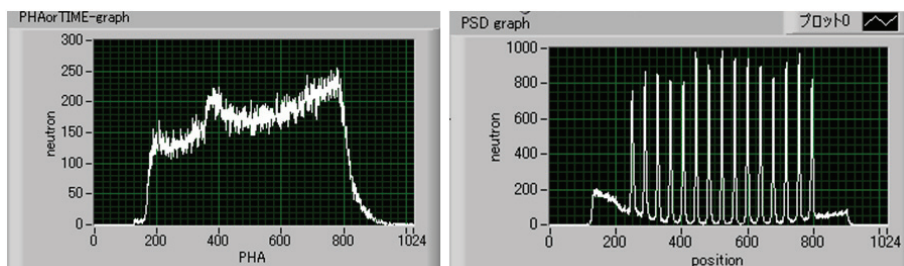


Fig. 4: The left part shows the pulse height distribution at a working high-voltage of 1300V. The wall effect is obviously seen. The right part shows the counts for different neutron incident position as the stage moved 5cm each step. Approximate 8mm position resolution (FWHM) is attained.

3.4. Electronics system design

The prototypical electronics system for ^3He LPSDs is being tested. It consists of charge-sensitive preamplifier modules and VME-based ADC boards. Each preamplifier module has 8 independent channels and one ADC board can handle 16 analog input channels, i.e., 8 LPSDs. The 6U VME crate can hold up to 20 standard cards and totally 10 pieces of ADC boards will be needed. The event-mode data are read out by a host computer via ethernet through a commercial VME controller.

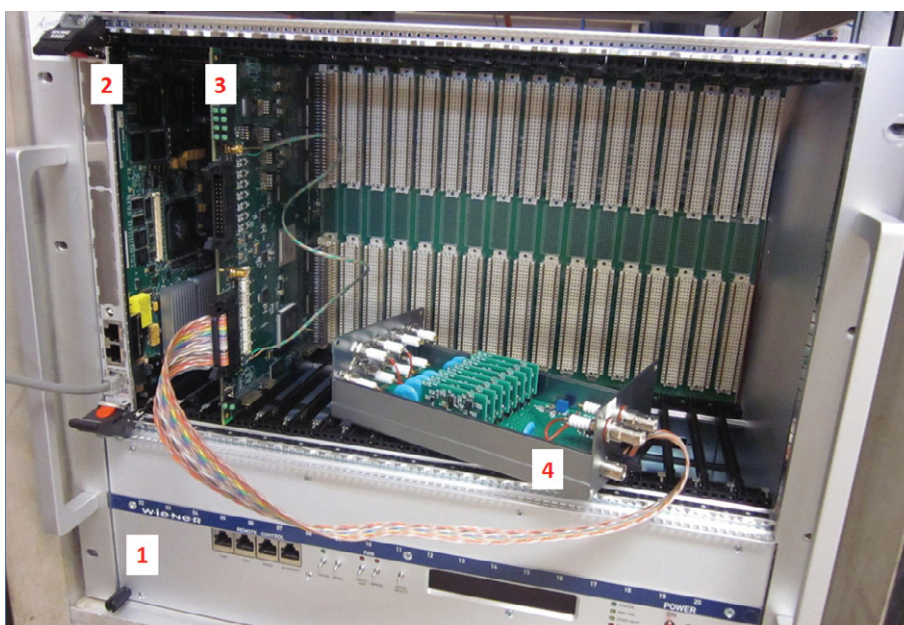


Fig. 5: The VME-based electronics system for ^3He LPSDs. (1) Commercial 6U VME crate, (2) VME controller (module MVME55006E), (3) VME-based ADC board, (4) Preamplifier module (8 channels).

4. Summary

The final physical design of the new TOF-SANS instrument of CPHS have been reviewed and engineering construction has began. Some parallel R&D are in progress and their preliminary results are satisfactory. The SANS at CPHS could well be China's first experience with pulsed SANS technique. We anticipate a

gradual improvement and upgrade processes throughout the initial commissioning to operation period, eventually attaining a performance level beneficial to education, research and technical development.

Acknowledgments

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References

- [1] See C.-K. Loong et al. in this proceedings.
- [2] See T.C. Huang et al. in this proceedings.
- [3] See T.C. Huang et al. in this proceedings.
- [4] S. Satoh et al., Nucl. Instr. and Meth. A, 529 (2004) 421-424.